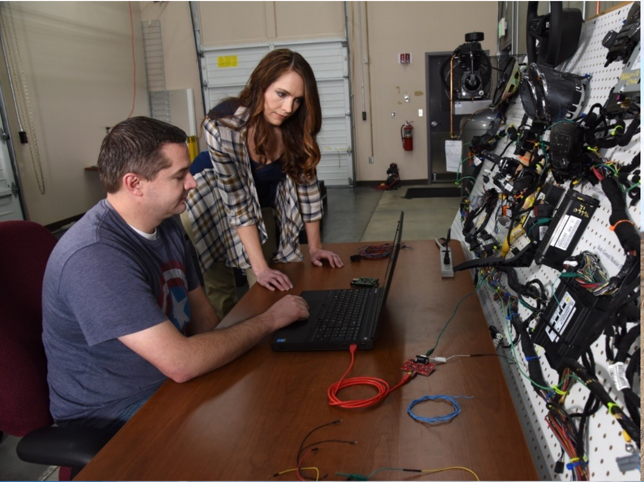


August 7, 2023

Virginia Wright
Cyber-Informed Engineering
Program Manager

CRITICAL CONSEQUENCES

RETHINKING THE CYBER PROTECTION OF CRITICAL INFRASTRUCTURE

RESEARCH MENTIONED IN THIS PRESENTATION WAS DEVELOPED WITH FUNDING FROM THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA) AND THE DEPARTMENT OF ENERGY.

INL Idaho National Laboratory

INL Background

- One in a network of 17 DOE national labs
- DOE’s lead lab for nuclear energy
- A major center for National Security

5,690 Employees | 511 Interns | $1.5 B Budget | 255 Patents

INL Mission
Our mission is to discover, demonstrate and secure innovative nuclear energy solutions, other clean energy options and critical infrastructure.

INL Vision
INL will change the world’s energy future and secure our critical infrastructure.

Research in the National Interest that **Maintains American Competitiveness & Security**

National and Homeland Security Focus Areas

INL is engaged worldwide solving *urgent* national security challenges in critical infrastructure protection and resiliency, nuclear and radiological security, and national defense.

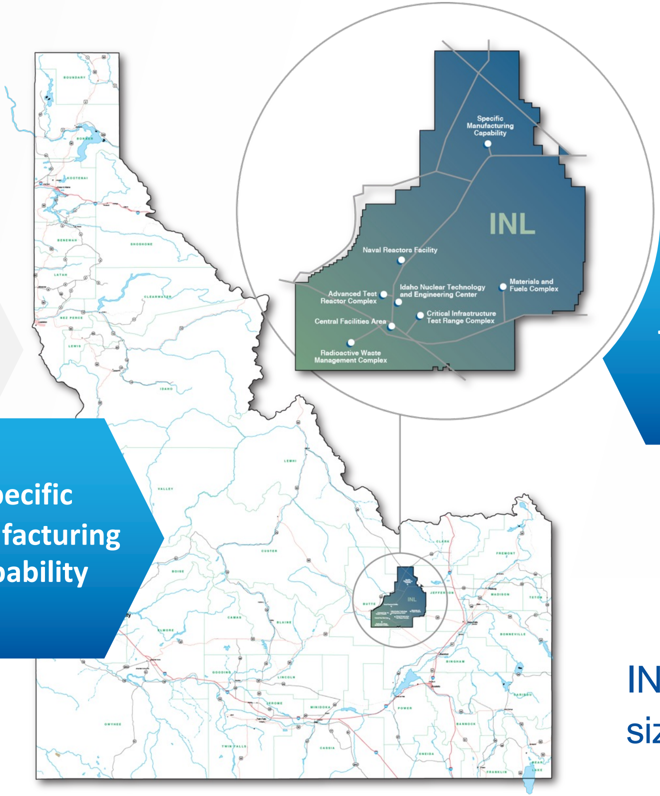
Unique Infrastructure and Capabilities

Electric Grid Test Bed

Water Security Test Bed

Specific Manufacturing Capability

Radiological Ranges



Cyber and Energy Security Labs

Nuclear Materials Facilities

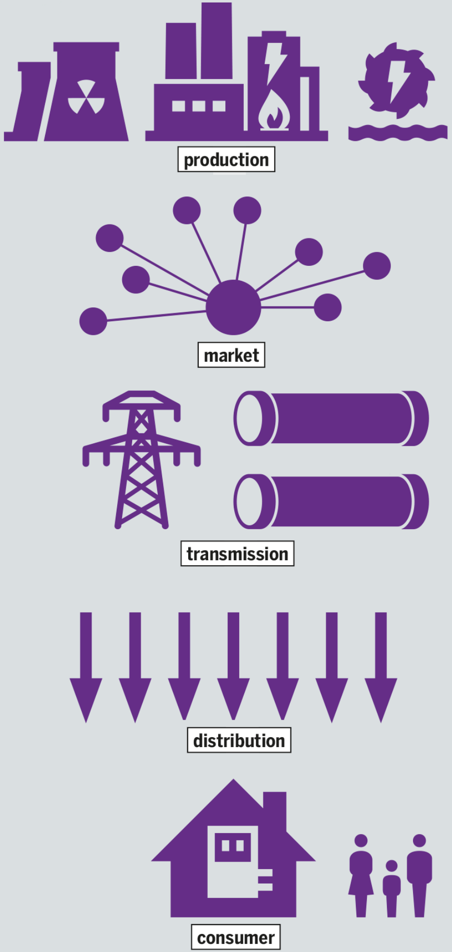
Explosives Test Range

Wireless Test Bed

INL covers 890 square miles, nearly the size of Rhode Island.

Energy Portfolio Research Focus

- Programs aimed to increase the cybersecurity of the energy grid
  - Focused on generation, transmission and distribution



Graphic: Bartz/Stockmar (M), CC BY 4.0

What is Cybersecurity?

(1) Prevention of damage to, protection of, and restoration of computers, electronic communications systems, electronic communications services, wire communication, and electronic communication, including information contained therein, to ensure its availability, integrity, authentication, confidentiality, and nonrepudiation.

Includes prevention, damage, restoration.
Includes immediate computing hardware and information on it
CIA triad plus authentication and non-repudiation (CIANA)

Definitions drawn from: https://csrc.nist.gov/glossary/term/cybersecurity

See also: https://www.securityscientist.net/blog/the-definition-of-cybersecurity-according-to-nist/

What is Cybersecurity (2)

- **(2)** The process of protecting information by preventing, detecting, and responding to attacks.

Attack-centric
Information-centric

What is Cybersecurity (3)

- **(3)** Measures and controls that ensure confidentiality, integrity, and availability of the information processed and stored by a computer.

The things we do

CIA

Information in motion and storage

What is Cybersecurity (4)

- **(4)** The ability to protect or defend the use of cyberspace from cyber attacks.

Attack-centric
Where, exactly, is cyberspace?

What is Cybersecurity (5)

- **(5)** The prevention of damage to, unauthorized use of, exploitation of, and—if needed—the restoration of electronic information and communications systems, and the information they contain, in order to strengthen the confidentiality, integrity and availability of these systems.

Includes damage, unauthorized use, and exploitation

Includes restoration

Communications-systems and information

Strengthen CIA

What is Cybersecurity (6)

- **(6)** Prevention of damage to, protection of, and restoration of computers, electronic communications systems, electronic communications services, wire communication, and electronic communication, including information contained therein, to ensure its availability, integrity, authentication, confidentiality, and nonrepudiation. For example, PNT data is generated by cyber systems. Protection of the devices and systems used to generate PNT data should be considered part of cybersecurity.

 # 1 with an example – Position Navigation and Timing

NIST definition of PNT: All information used to form or disseminate PNT solutions, including signals, waveforms, and network packets.

https://csrc.nist.gov/glossary/term/pnt_data

What is Operational Technology?

(1) Programmable systems or devices that interact with the physical environment (or manage devices that interact with the physical environment). These systems/devices detect or cause a direct change through the monitoring and/or control of devices, processes, and events. Examples include industrial control systems, building management systems, fire control systems, and physical access control mechanisms.

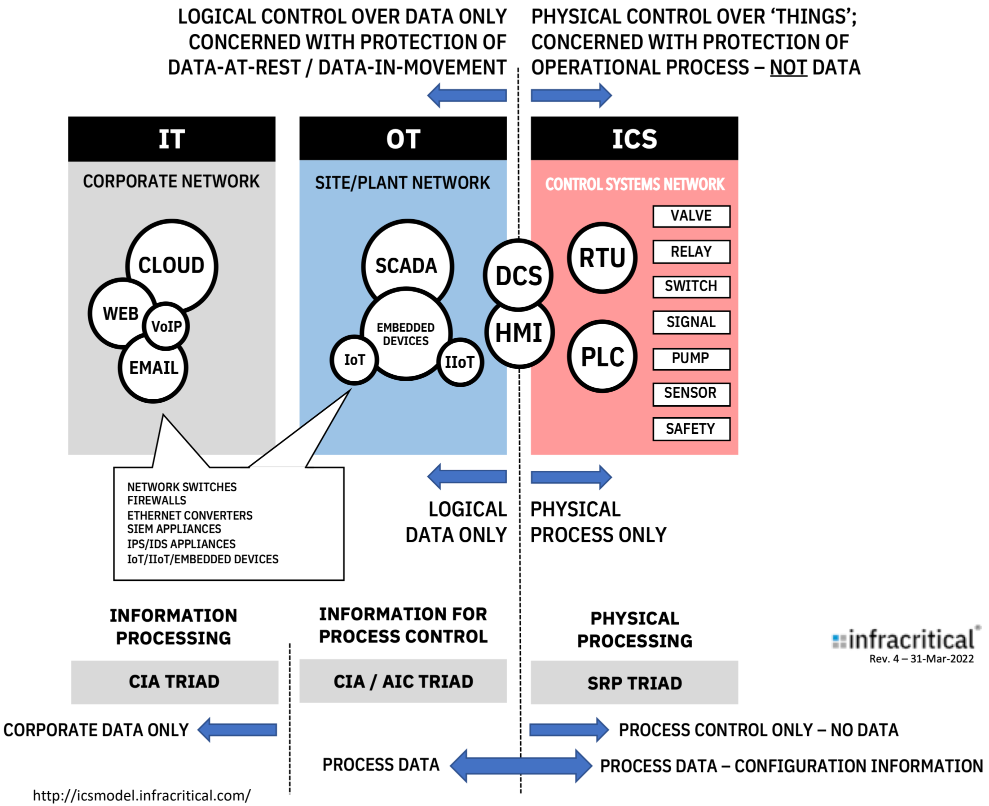
(2) The hardware, software, and firmware components of a system used to detect or cause changes in physical processes through the direct control and monitoring of physical devices.

(3) Programmable systems or devices that interact with the physical environment (or manage devices that interact with the physical environment).

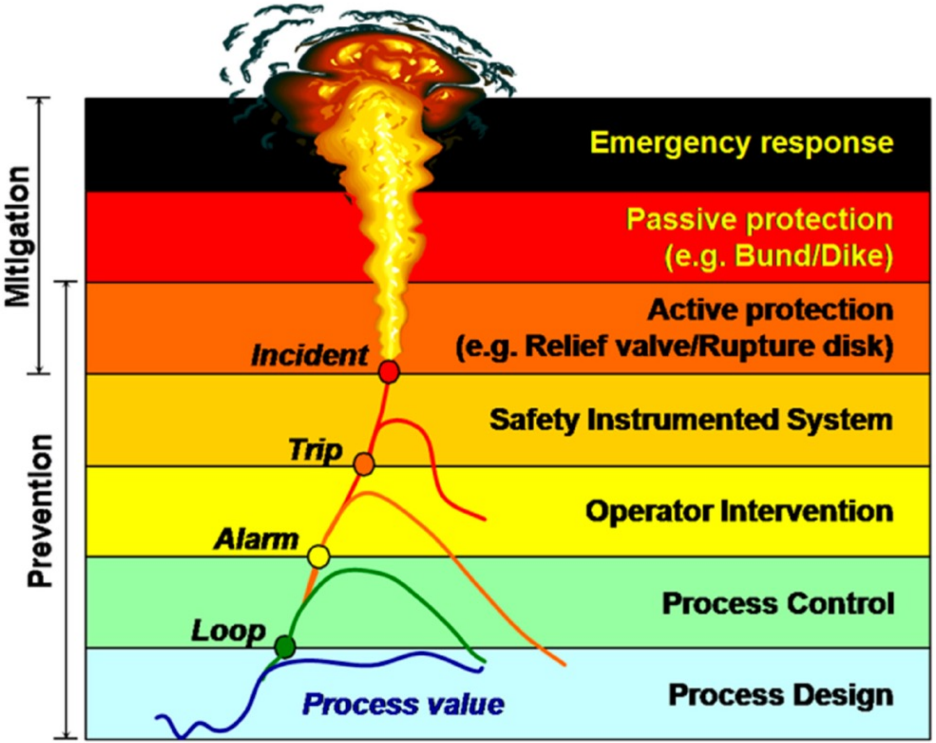
(4) Hardware and software that detects or causes a change through the direct monitoring and/or control of physical devices, processes and events in the enterprise.

https://csrc.nist.gov/glossary/term/operational_technology

Operational Technology vs Information Technology



Industrial Control Systems and Safety (LOPA)



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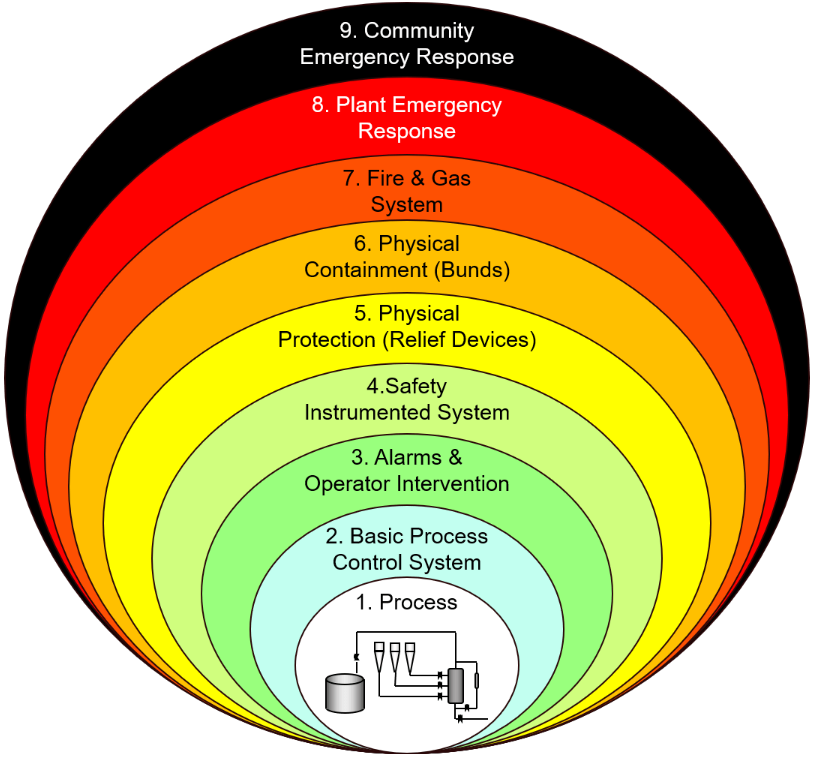
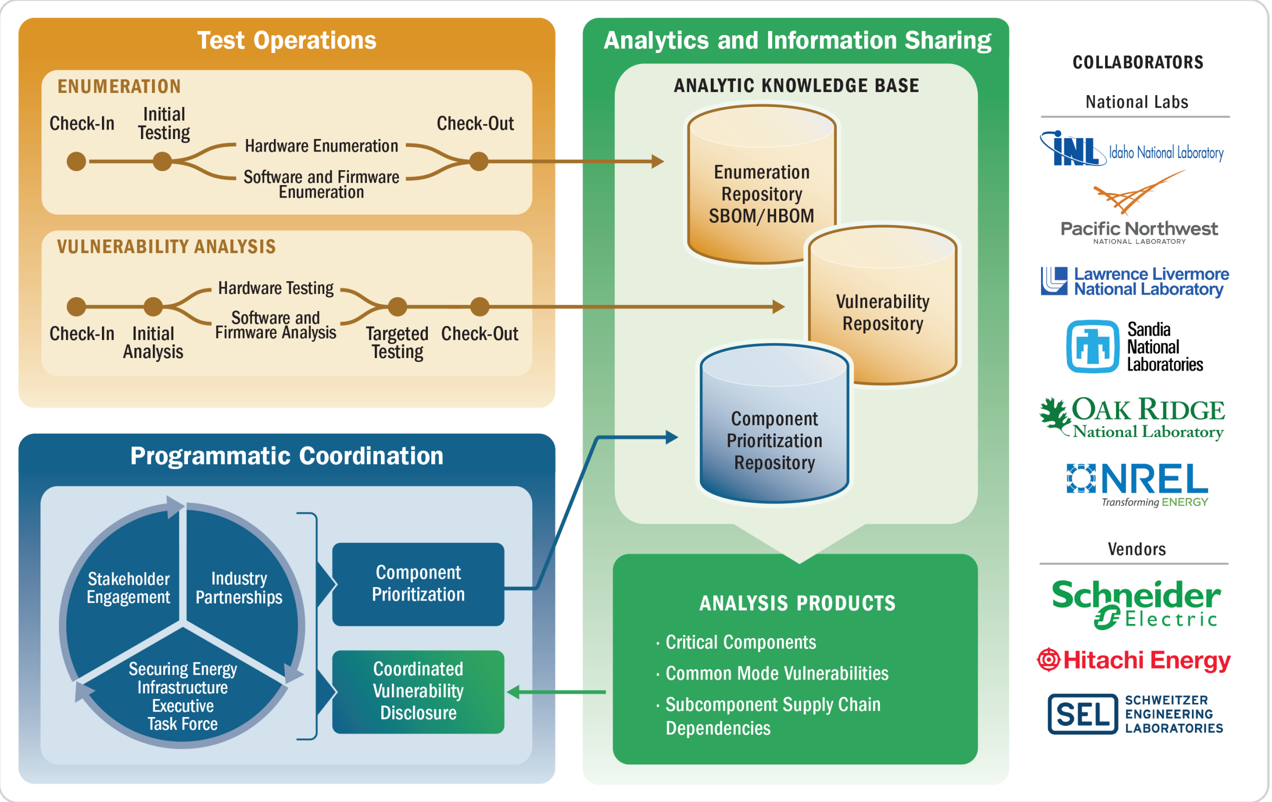


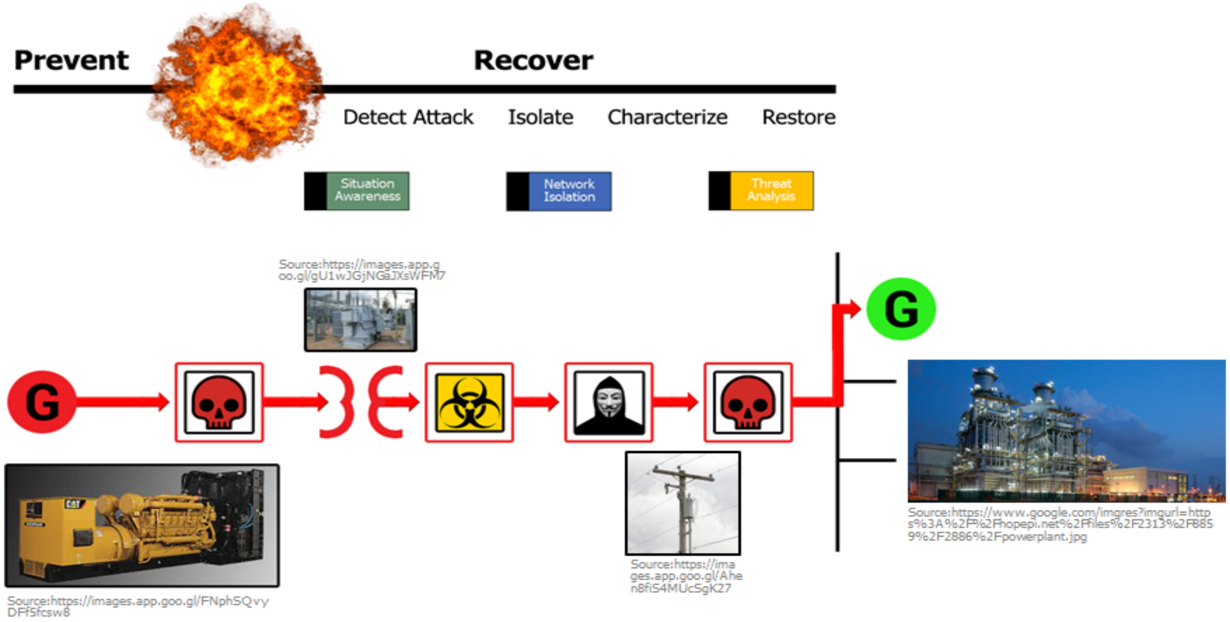
https://www.thesafetymaster.com/risk-management/lopa-sil/

Cyber Testing for Resilient Industrial Control Systems



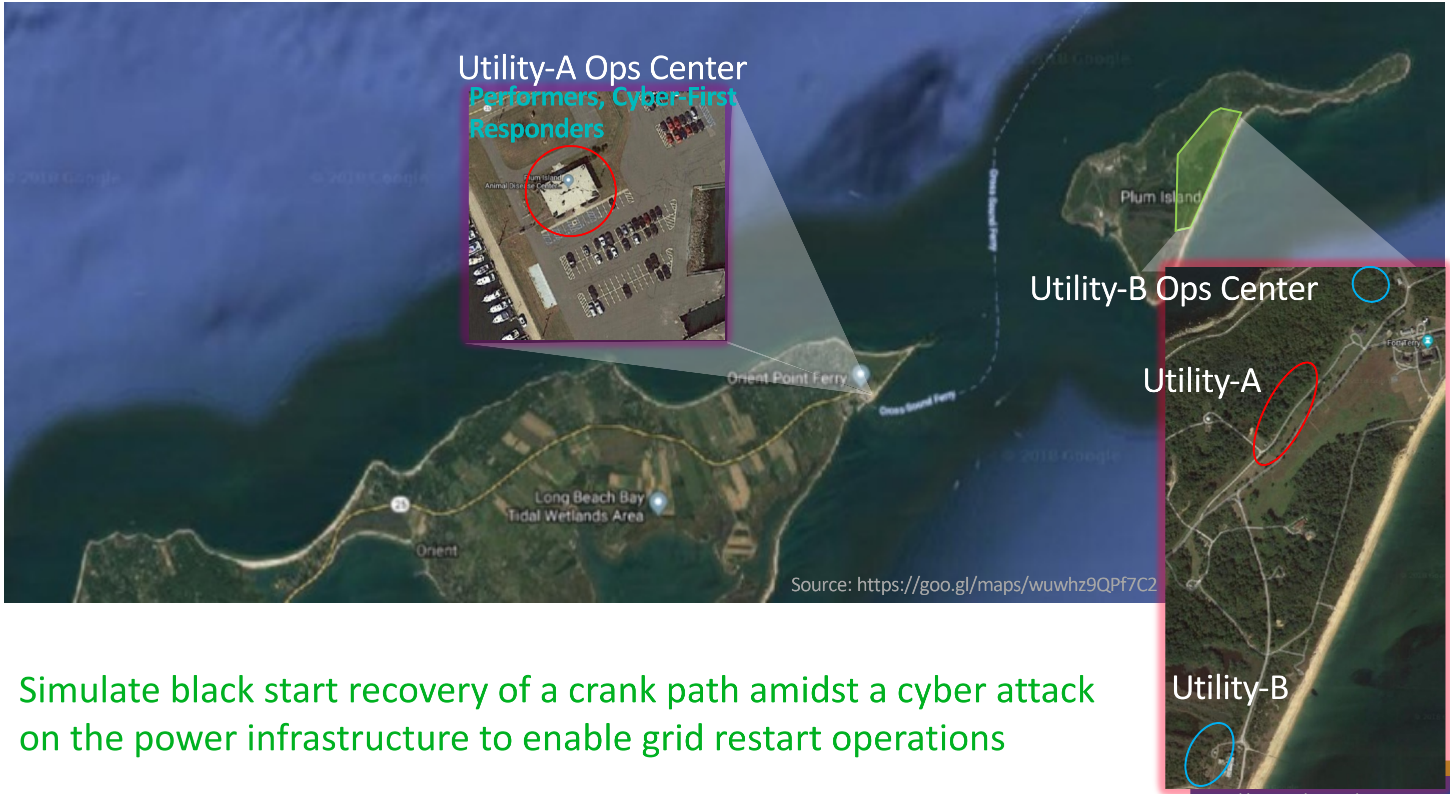
RADICS Program Objective and Goal

Objective: Enable black start recovery of the power grid amidst a cyber-attack on the energy sector's critical infrastructure.



Goal: Seven Days to Isolate, Characterize & Restore Crank Pathways

RADICS Exercises (Overview)

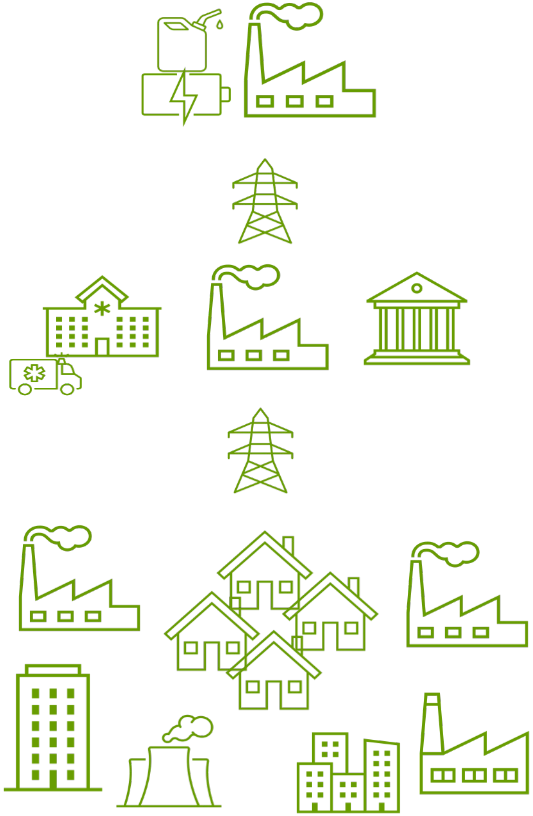


Simulate black start recovery of a crank path amidst a cyber attack on the power infrastructure to enable grid restart operations

Source: https://goo.gl/maps/wuwhz9QPf7C2

RADICS Exercise Assumptions

- Live ongoing cyber attack
  - Assets and network are pwned by attacker
  - Attacker can prevent typical “Black Start” restoration
- Reflashing and restoration are not a viable solution
- Operating in manual mode is not a long-term option
- Defenders are detecting attacker tools and “reclaiming” territory
- Tool creators must work with and through power operations team
- Goal is restoration of service and control of infrastructure



Important Industry Drivers for Energy

Geopolitical

- Extreme weather / climate change
- Transition to clean energy
- Largest single federal investment in energy infrastructure
- Continued dependence on fossil fuels
- International ONG market instability
- Instability in clean energy supply chains
- Increased protectionism of US production
- Pressure on uranium production
- Nuclear industry slow to expand
- National extremism on the rise

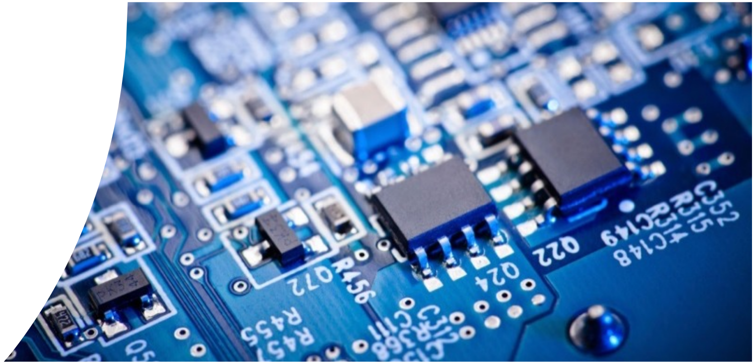
Important Industry Drivers for Energy

Technological

- Energy diversity requires digitization, automation, integration, and orchestration
- Large changes in features and capabilities of seemingly familiar products
- Continued LONG deployments (decades)
- IT-class technology being incorporated into OT solutions
- Engineers less involved in design and operations
- Industry moving to cloud for data aggregation and in some cases, control
- Digital technology inherently vulnerable (Icefall)
- Many green energy solutions require continuous network connectivity
- Changing generation and load profiles, especially in distribution

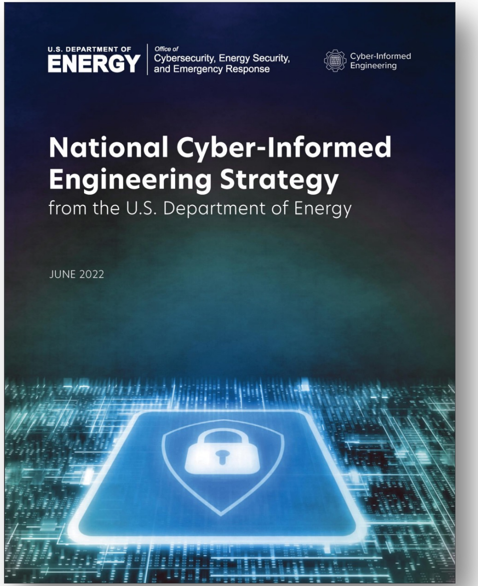
Cyber-Informed Engineering (CIE)

- CIE uses **design decisions and engineering controls** to eliminate or mitigate avenues for cyber-enabled attack.
- CIE offers the **opportunity to use engineering to eliminate specific harmful consequences** throughout the design and operation lifecycle, rather than add cybersecurity controls after the fact.
- Focused on **engineers and technicians**, CIE provides a framework for cyber education, awareness, and accountability.
- CIE aims to engender a **culture of security** aligned with the existing industry safety culture.

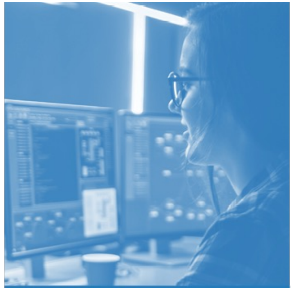
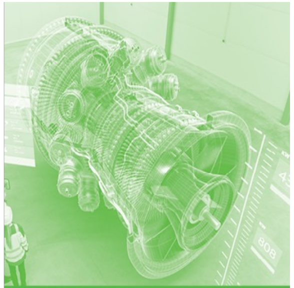


National CIE Strategy

- Directed by the U.S. Congress in the Fiscal Year 2020 National Defense Authorization Act
- Outlines core CIE concepts
  - Defined by a set of design, operational, and organizational principles
  - Place cybersecurity considerations at the foundation of control systems design and engineering
- Five integrated pillars offer recommendations to incorporate CIE as a common practice for control systems engineers
  - Intended to drive action across the industrial base stakeholders—government, owners and operators, manufacturers, researchers, academia, and training and standards organizations
- DOE issued the National CIE Strategy June 15, 2022



Pillars of the National CIE Strategy

Awareness	Education	Development	Current Infrastructure	Future Infrastructure
Promulgate a universal and shared understanding of CIE	Embed CIE into formal education, training, and credentialing	Build the body of knowledge by which CIE is applied to specific implementations	Apply CIE principles to existing systemically important critical infrastructure	Conduct R&D and develop an industrial base to build CIE into new infrastructure systems and emerging technology

CIE Principles

Principle	Key Question
Consequence-Focused Design	How do I understand what critical functions my system must <u>ensure</u> and the undesired consequences it must <u>prevent</u>?
Engineered Controls	How do I implement controls to reduce avenues for attack or the damage which could result?
Secure Information Architecture	How do I prevent undesired manipulation of important data?
Design Simplification	How do I determine what features of my system are not absolutely necessary?
Resilient Layered Defenses	How do I create the best compilation of system defenses?
Active Defense	How do I proactively prepare to defend my system from any threat?
Interdependency Evaluation	How do I understand where my system can impact others or be impacted by others?
Digital Asset Awareness	How do I understand where digital assets are used, what functions they are capable of, and our assumptions about how they work?
Cyber-Secure Supply Chain Controls	How do I ensure my providers deliver the security we need?
Planned Resilience	How do I turn “what ifs” into “even ifs”?
Engineering Information Control	How do I manage knowledge about my system? How do I keep it out of the wrong hands?
Cybersecurity Culture	How do I ensure that everyone performs their role aligned with our security goals?

Getting Involved

EMAIL CIE@INL.GOV

CIE COP and Working Group Purpose

Cyber-Informed Engineering COP

Starting Jan. 2023

Quarterly

Next Meeting – July 12, 2023, 11AM MT / 1 PM ET

Multi-stakeholder team to aid the translation of CIE into technical requirements that can inform guidance, practices, and standards development

CIE Education WG

Monthly starting Feb. 2023

3rd Wednesday, 9 AM MT / 11 AM ET

Develop curricula and materials that integrate CIE principles into engineering degree programs

CIE Development WG

Monthly starting Feb. 2023

4th Wednesday, 9 AM MT / 11 AM ET

Develop CIE implementation guidance and an open-source library of resources

CIE Standards WG

Monthly starting Aug. 9, 2023

1st Wednesday, 9 AM MT / 11 AM ET

Support integration of CIE into engineering and cybersecurity standards

Upcoming CIE Presentations and Outreach

Save the Date: Cyber-Informed Engineering Practitioner's Workshop – Multiple presentations and panels for CIE practitioners

Register for the workshop: https://mccrary.auburn.edu/events/cie-practitioners-workshop/

Recent CIE Publications

- **SANS ICS Concepts Video:** https://youtu.be/o_vIxW6UTeg
- **CIE Workbook:** https://www.osti.gov/biblio/1986517
- **Industrial Cyber**: CIE and CCE Methodologies Can Deliver Engineered Industrial Systems for Holistic System Cybersecurity (June 11, 2023) with interviews from INL, 1898, and West Yost
- **Harvard Business Review**: Engineering Cybersecurity into U.S. Critical Infrastructure (April 17, 2023) by Ginger Wright, Andrew Ohrt, and Andy Bochman
- **Shift Left video podcast on GrammaTech blog**: Shifting Left for Energy Security (April 4, 2023) with Ginger Wright, Idaho National Lab and Marc Sachs, Auburn University
- For more CIE articles and publications, visit: inl.gov/cie

Next Steps for CIE

- Expanded CIE Implementation Guidance
- Benefits quantification methodology
- Survey of applicable standards
- Multiple Curriculum Resources
  - Exercises
  - Training Guides
  - Lesson Plans
- Tool for Applying CIE at Varying Criticality Levels
- CIE Validation Methods